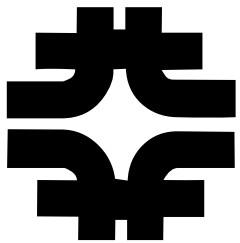
On Tevatron Lifetimes,

Beams, Luminosity & Spot size



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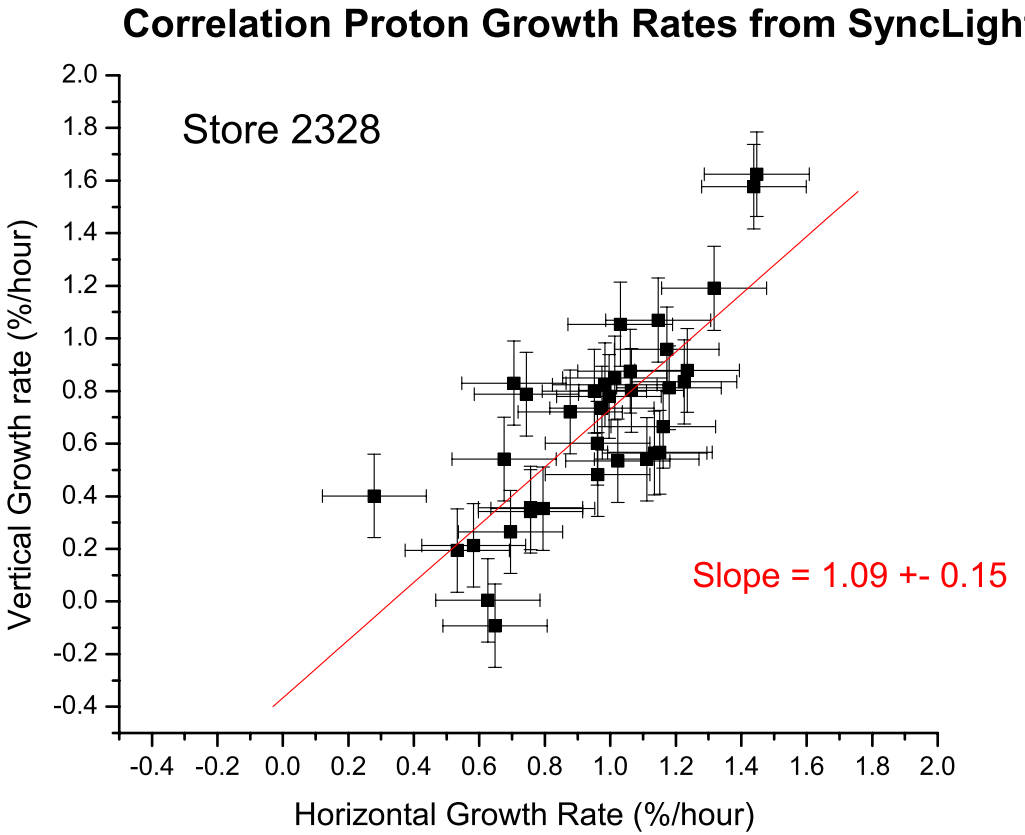
April 4 2003

Study Goals

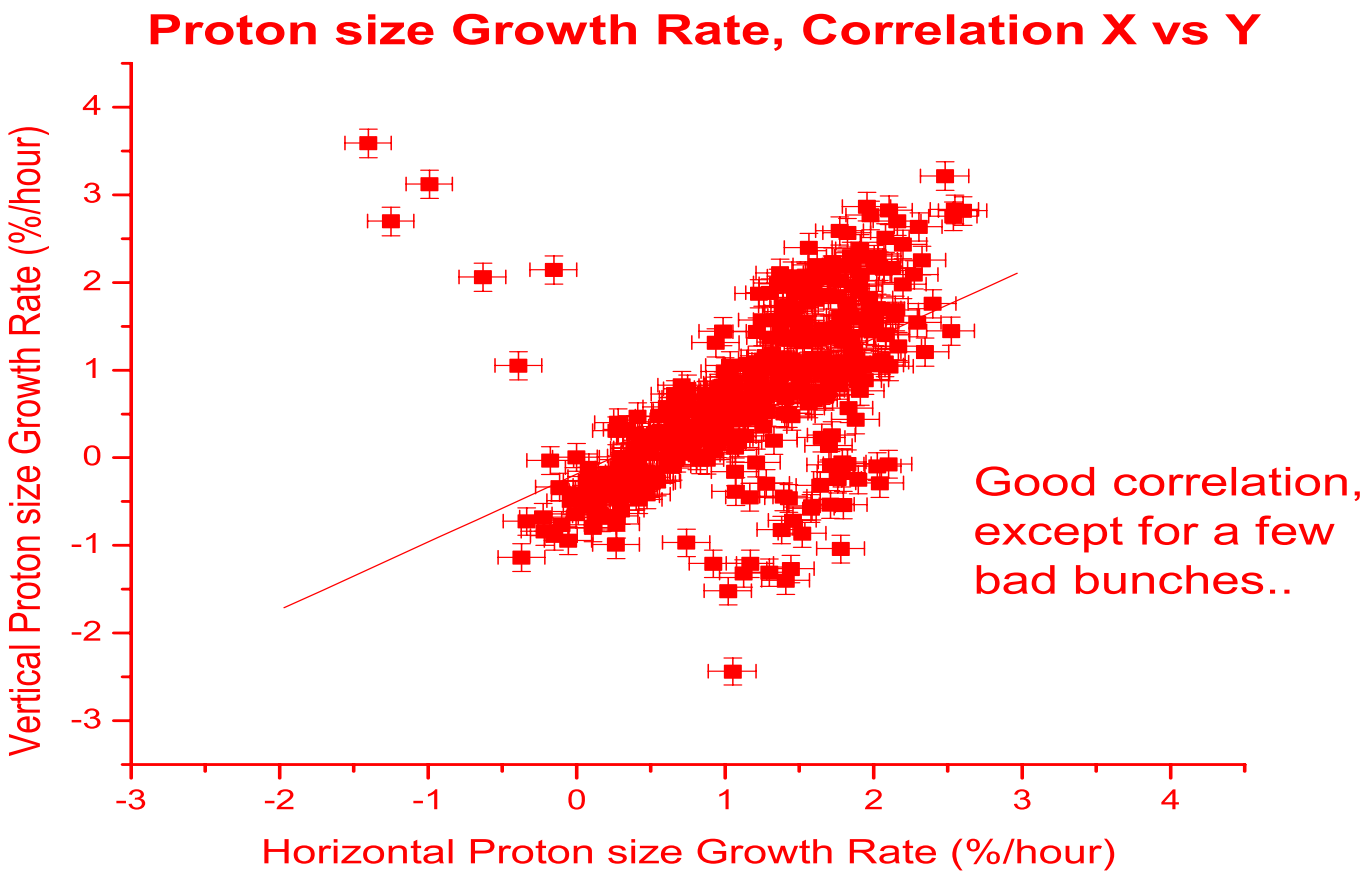
- Luminosity Lifetime , term by term..Does it add up ?
  - Previous studes showed that it does add up, with ~5 to 10%, relative.
- If not, may be the Sync Lite Transverse beam size growth rate are wrong.
  - The Pbar scale is still a mystery.
  - What if the measured spot size is driven by two terms, a “instrumental constant term” and a beam size term, which change with time during the store.
  - => establish that we understand (or not) the transverse size growth rate from luminosity lifetime measurements.

Sync Lite Beam Transverse Size Growth Rate Measurements: Protons, store 2328

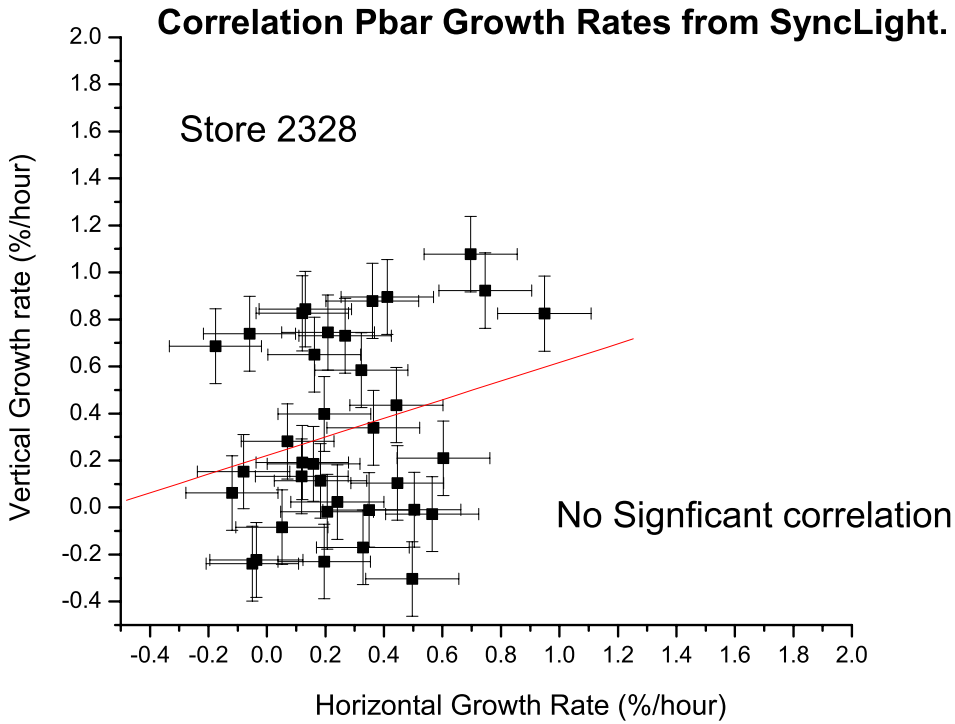


- For the record store, transverse size growth was actually a bit smaller than usual, may be because the proton lifetime was not very good. (the emittance already reached it's quasi saturation value.
- Good Correlation between X and Y (TeV strongly coupled.)

Sync Lite Beam Transverse Size Growth Rate Measurements: Protons, Many Recent stores

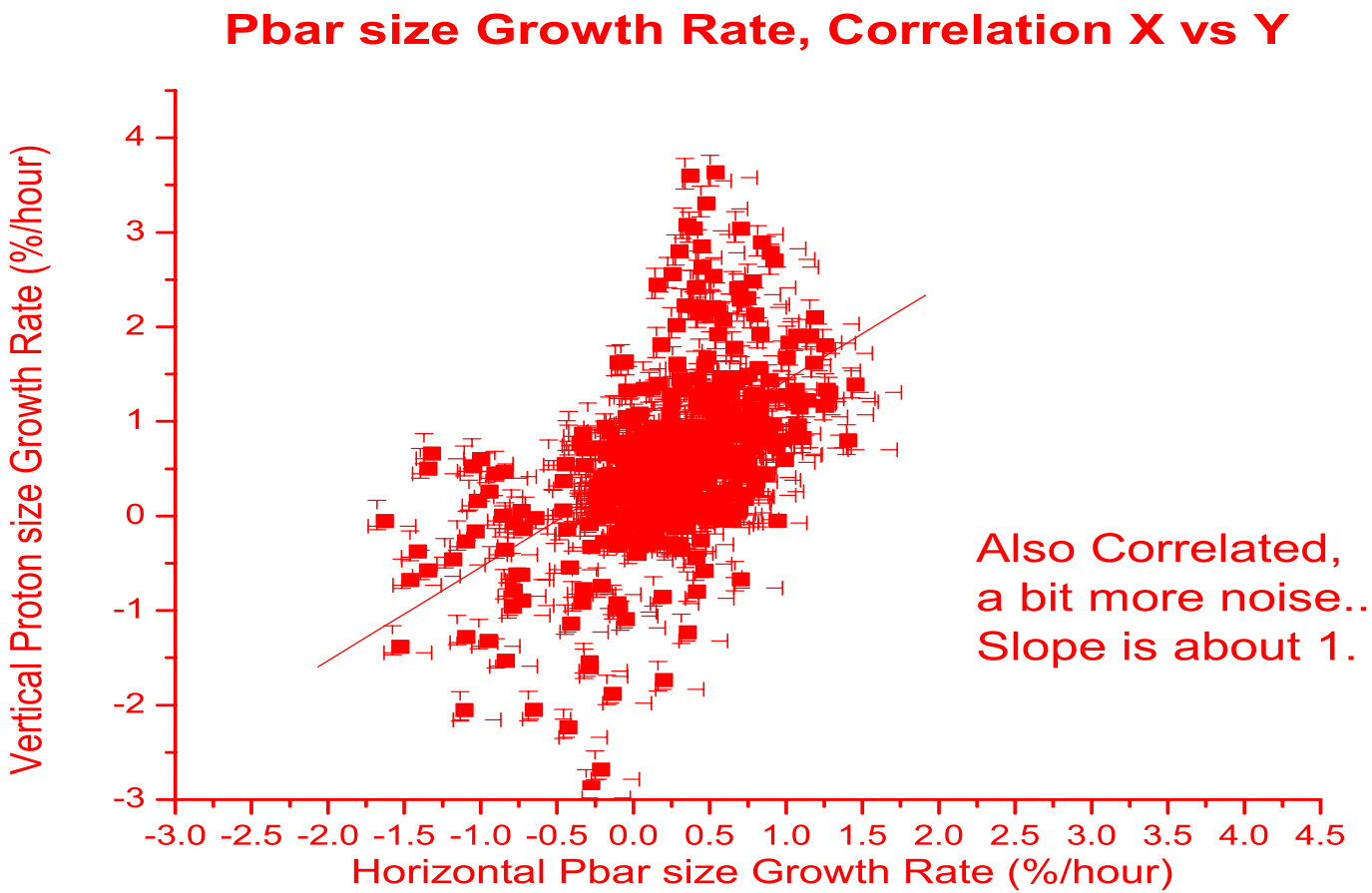


Sync Lite Beam Transverse Size Growth Rate Measurements: AntiProtons, store 2328



- Pbar transverse size growth rate are smaller than proton.
- Not too surprising (IBS is weaker, due to smaller bunch intensities .. To be tested qunantitatively..
- Or, admittedly, we have a problem with Pbar Sync Lite.

Sync Lite Beam Transverse Size Growth Rate Measurements: AntiProtons, many stores



Effective Transverse Size or Emittance Rate Changes or Inverse Lifetime.

$$\sigma_{eff} \approx k_\sigma \sqrt{(I_p * I_a)/L}$$

$$\varepsilon_{eff} \approx k_\varepsilon (I_p * I_a)/L$$

$$\frac{d\varepsilon}{2\varepsilon dx} = \frac{d\sigma}{\sigma dx} = 1/2 * (1/\lambda_L - 1/\lambda_p - 1/\lambda_a)$$

$$I_p = I0_p * e^{-t/\lambda_p}, I_a = I0_a * e^{-t/\lambda_a}, L = L0 * e^{-t/\lambda_l}$$

Effective Transverse Size, Components.

$$\frac{d\sigma}{\sigma dx} = (S_p + S_a + \frac{dF}{2Fdx})$$

$$S_{p(a)} = \frac{d\sigma_{p(a)}}{\sigma_{p(a)} dx} * \frac{1}{\left(1 + \varepsilon_{a(p)} / \varepsilon_{p(a)}\right)}$$

Emittance rate changes are double the size rate changes. The last Comes from the the hour glass factor, I.e., k in previous is not Constant.

Hour Glass Factor.

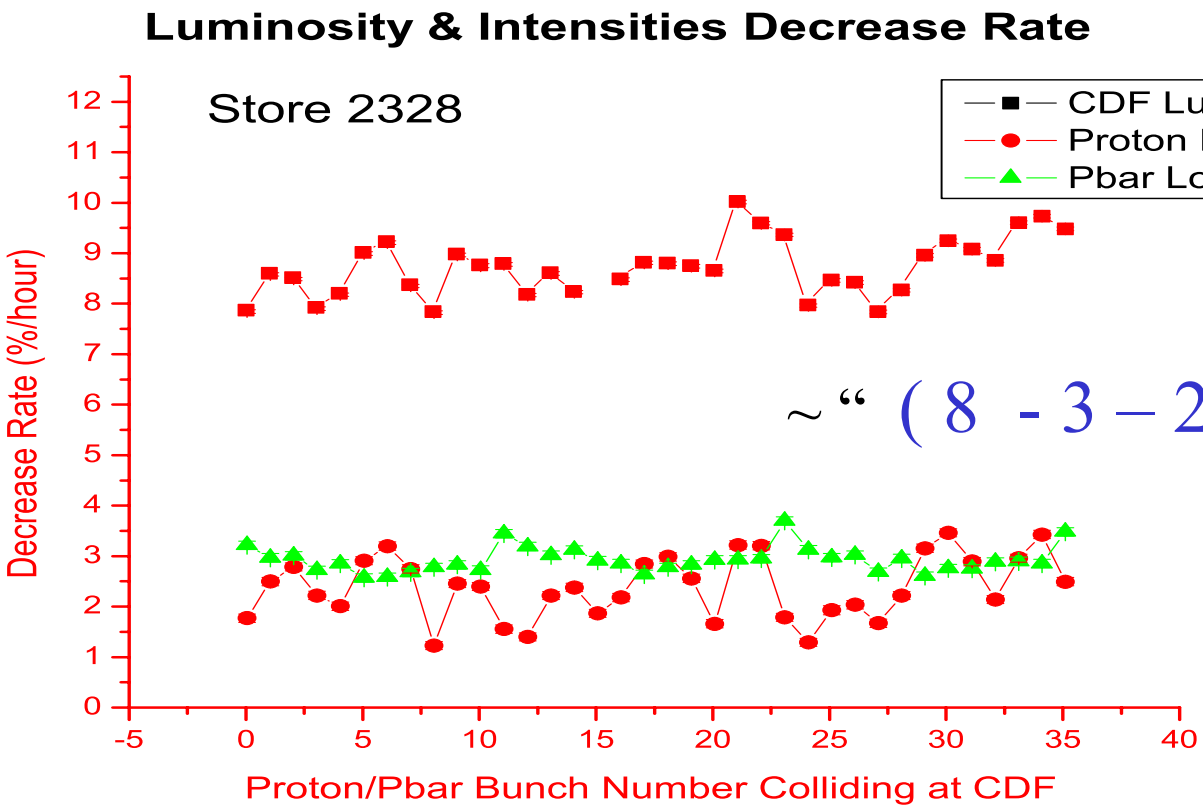
$$\sigma^*_\beta = \sigma \text{ (ns)} * 29.98 / \beta^*$$

$$F = 1.1117 - 0.62504*\sigma^*_\beta + 0.19358*\sigma^{*2}_\beta - 0.02442*\sigma^{*3}_\beta$$

Polynomial expression from M. Church
Beta* assumed to be 35.6 cm. Bunch Length from SBD

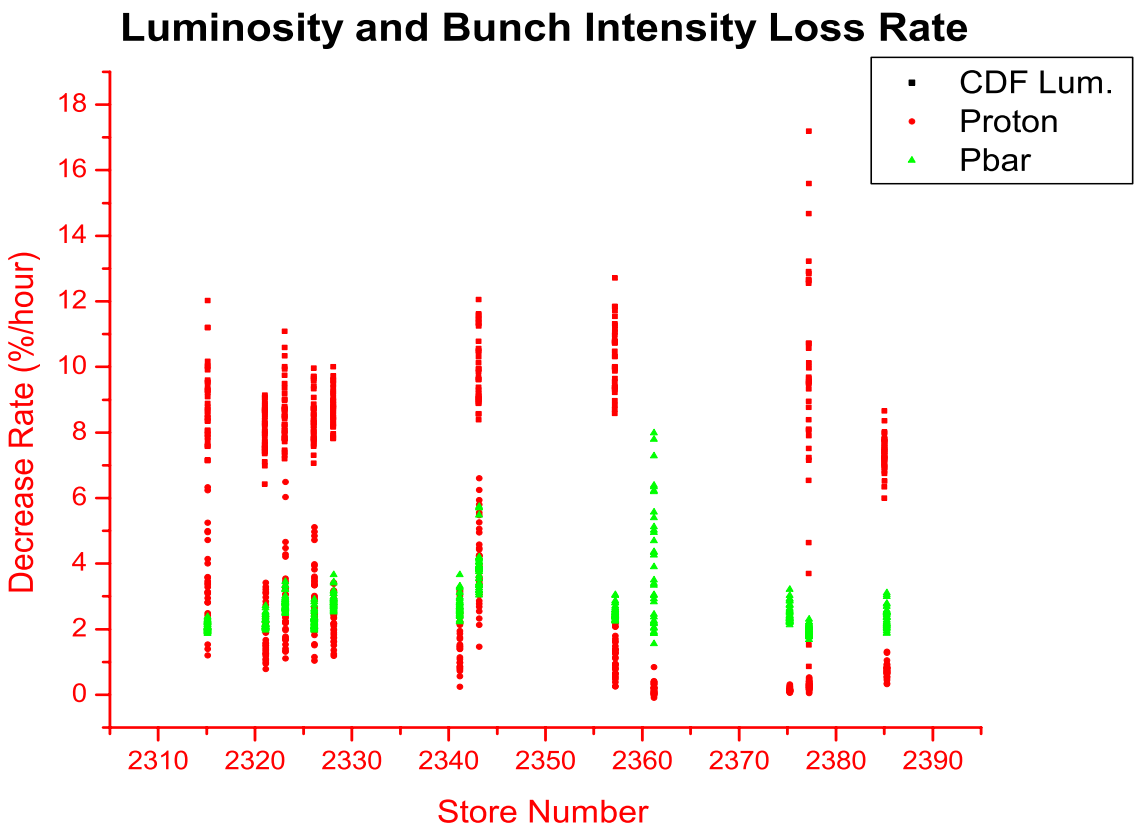
Derivative computed from this polynom

Numerically… Making a big difference..



~ “ (8 - 3 – 2) %/hour“

For more stores..

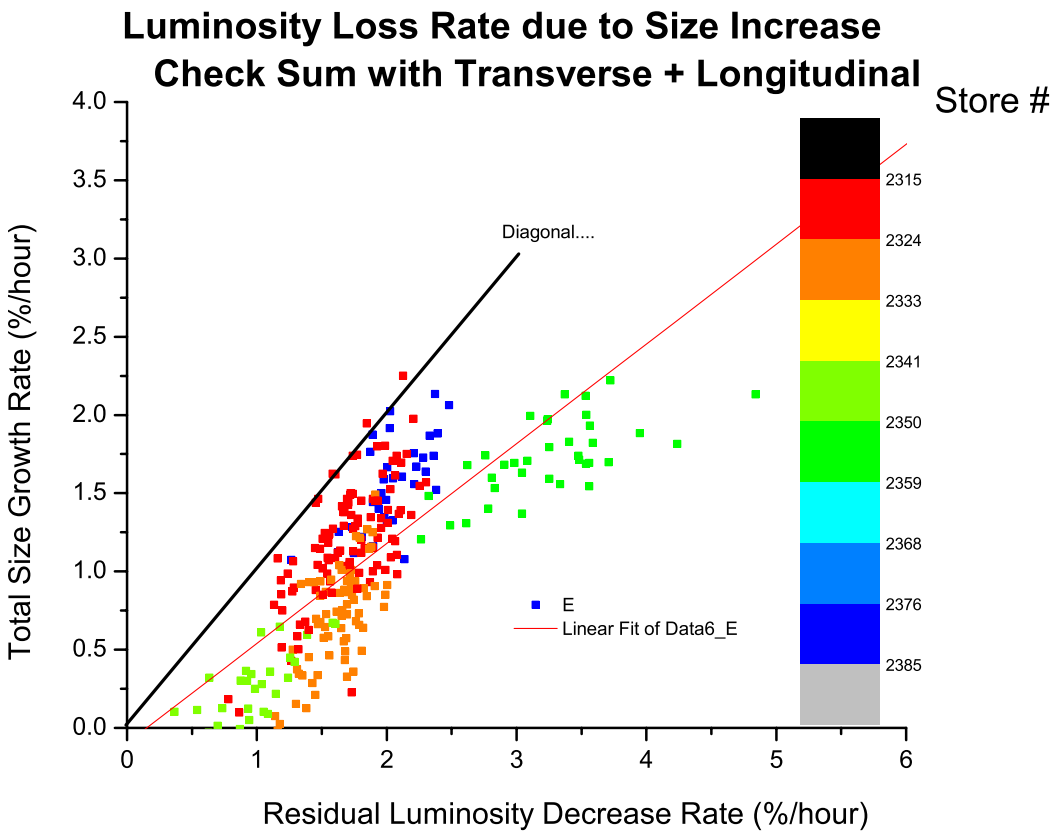


We are looking
For
Black –
Red – Green.

Large fluctuations.

What are the errors?

Result for ~ 10 Recent stores.

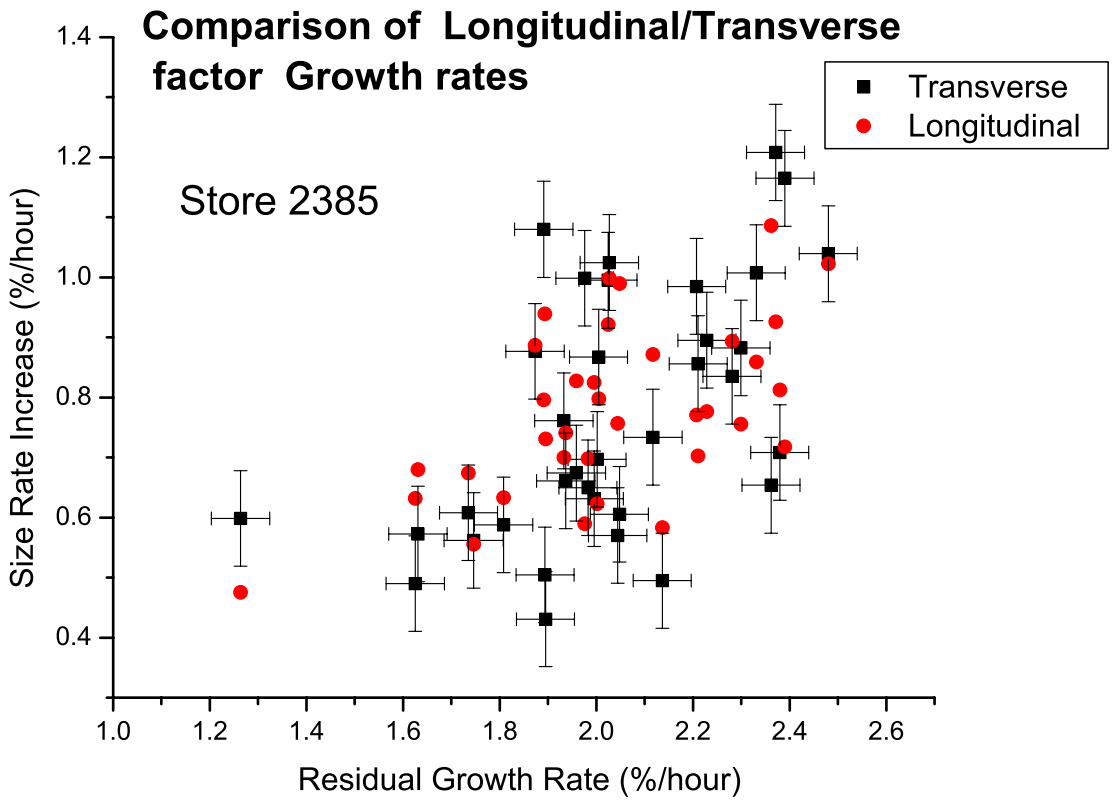


There seems to be a small deficit (~0.5% per hour) in the measured (Sync Lite, SBD) effective spot size, or emittance.

Is this signficant?

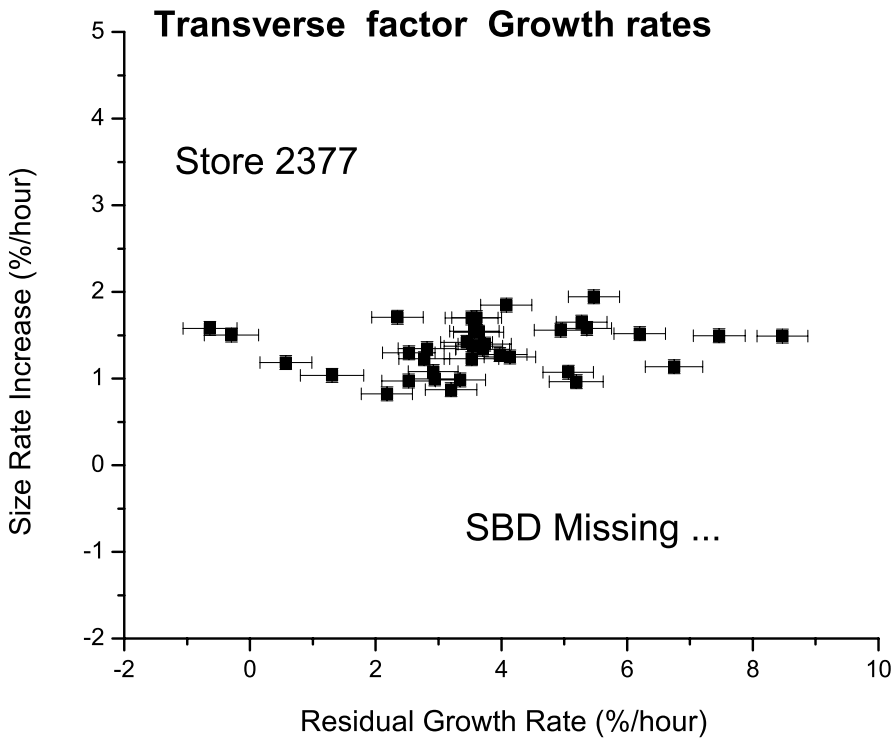
On a statistical basis, It seems so.

Transverse/Longitudinal Growth Rates.



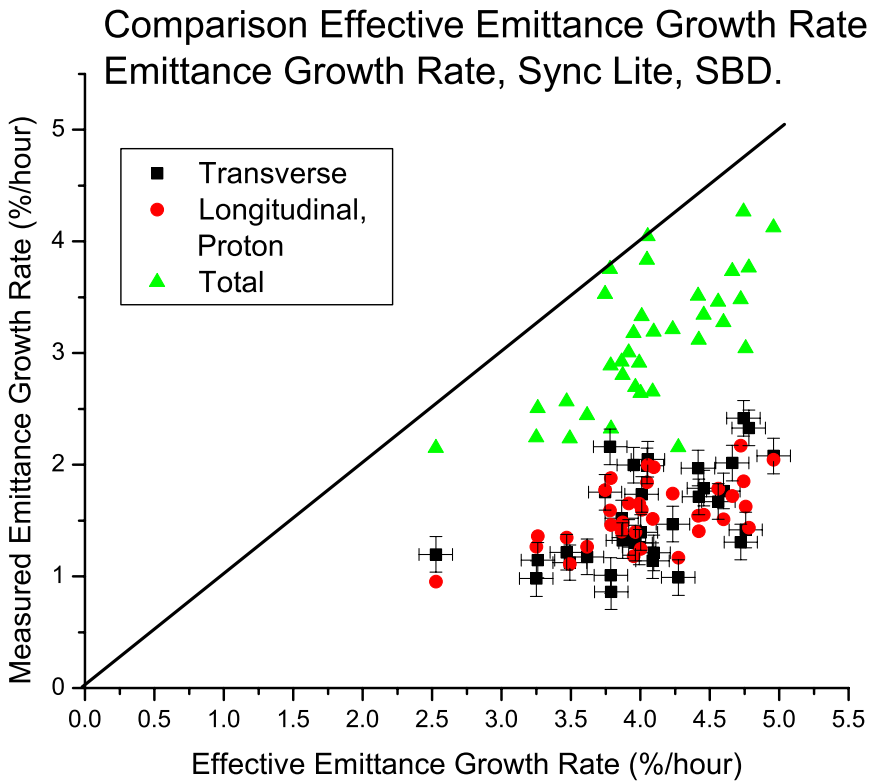
- The hour glass factor counts! As significant as the transverse growth rate.
- So, to establish a "Pbar problem", one muse improve on the accuracy of these measurement.
- New SBD software (A. Tollestrup) will help.
- Precision Limited.!

For Store 2377



- Store 2377 is a bit anomalous
- SBD was missing (Front-end or Data Acquisition..)
- Hard to make something out of one store.

For Store 2385



- Error bars from Longitudinal effects not taken into account.

Comparison with Vladimir Calculation, store 2385

Growth Rate, Emitt.	V. Shiltsev (%/hour)	this work(%/hour)
Effective emittance	4.35	4.13 +- 0.514
Pbar, Horizontal	0.625	0.124 +- 0.43
Pbar, Vertical	-0.1	0.575 +- 0.64
Proton Horizontal	3.03	3.30 +- 0.29
Proton Vertical	2.78	2.19 +- 0.83
Longitudinal	-	1.56 +- 0.29
Total Emitt	1.58	3.10 +- 0.41

V.S. has a “factor 3 discrepancy”, Longitudinal effects do not totally explain the difference.

Tentative Conclusion.

Luminosity Lifetime "check-sum" is not quite understood: there seems to be a systematic under-estimation of the measured emittance terms, at the level of 0.5%/hour (~5 % relative)

We have however no strong, direct evidence that the Pbar Sync Lite Transverse Size Rate increase is "wrong".

Difficult analysis, too many subtractions. Longitudinal effects might be relevant.

Should compare Pbar SyncLite Growth Rate with IBS prediction for Pbar. (code is written, have not had time yet to look at data..)